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LATERAL VERTEBRAL DIMENSIONS AND LATERAL SPINAL CURVATURE[1]

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THE individual bones of the vertebral column, particularly the bilateral dimensions of the vertebral bodies, are of interest because of their possible contribution to lateral curvature. Detailed observations and measurements of individual vertebrae and of the column as a whole have in the past been directed principally toward the anterior and posterior vertical heights of the bodies and their relation to sagittal plane curvature (Turner, 1886; Trotter, 1929), numerical and structural variations in the vertebrae (Willis, 1923; Lanier, 1939), and asymmetries of the various processes (Whitney, 1926; Lanier, 1939).

Studies of lateral curvature and of asymmetry of the vertebral column have been made by workers in several fields. Clinicians have been interested in the marked asymmetry that characterizes pathological scoliosis. A less marked asymmetry of the vertebral column has interested anatomists. Recent standard textbooks refer briefly to the presence of a slight lateral curvature to the right in the thoracic region. Among them may be cited Piersol (1930), Gray (1942), Morris (1942), and Cunningham (1943). Equally briefly it is stated that the curvature

[1] The writer acknowledges with thanks the help and criticism of Dr. Mildred Trotter throughout the period of this study.

is thought to be due to the greater use of the right arm or to the pressure made by the aorta. In order to determine the origin of these explanations the literature has been surveyed. In 1733, in Cheselden's *Osteographia,* the 3rd and 4th thoracic vertebrae were described as being: "bent to the right side for the better situation of the heart, which makes that side of the breast more convex than the other, and therefore stronger; which seems advantageous to the right arm, its motions depending upon the support it receives from the breast. Hence, I think, it seems that the almost universal preference of that arm is not an arbitrary thing, but founded upon observation, that it is capable of more perfect actions than the other." This same description and explanation appeared in Cheselden's *The Anatomy of the Human Body* (1756 and 1806). In 1792 *A Compendious System of Anatomy* included a description of anteroposterior curves but no mention was made of lateral curvature. *Anatomia Britannica* (1808) presented a description of the anteroposterior curves but lateral curvature was not mentioned. Fyfe (1823) described the several curves of the spine which are seen in a lateral view but added that the spine appears to be straight when viewed anteriorly or posteriorly. Humphry (1858) recognized the existence of a slight lateral curvature in the middle and upper part of the back, with slight compensatory curves above and below. He doubted that the cause was the pressure of the aorta because the curve is not present at birth and, in a case in which the aorta was found on the right side of the column, the curve of the column was still to the right. His belief that the greater use of the right arm is the determining factor was supported by knowledge of the case of a left-handed individual in whom the lateral curvature was to the left. Leidy (1861), in his treatise on anatomy, mentioned the occurrence of lateral curvature and he too stated that it can be attributed to the habitual use of the right upper limb. Sappey (1867) referred to the groove for the aorta as a factor in lessened resistance in the upper thoracic region and gave this region as one frequently showing deviation of the vertebral column. In 1882 both Quain and Allen included references to a slight degree of lateral curvature of the vertebral column to the right. The greater use of the right arm was the explanation given. A few years later Lane (1887) described the body of a man who had been employed at heavy manual labor. The vertebral column was described as having two slight lateral curves, the upper formed by the 6th and 7th cervical and the upper 5 or 6 thoracic vertebrae and directed toward the right, the lower by the remaining thoracic and the 1st and

2nd lumbar vertebrae with its convexity directed to the left. Early in the twentieth century a series of papers was published in Germany which was concerned with the subject of the influence of the aorta on the vertebral column. The first of these was the report of an address by Spuler which was published in 1903. He pointed out that the aorta makes an impression on the bodies of the vertebrae, flattening them somewhat on the left sides, which makes the column appear to be curved to the right in the upper thoracic region. Because Spuler implied that the idea was original with him several other papers appeared within the following year (Gaupp, 1903; Hanson, 1904; Tandler, 1904) which gave evidence that this phenomenon had been observed previously and was well known to all investigators.

Among recent writers Grant (1940) is an exception in that he does not describe a curvature in the thoracic region, although he mentions a flattening of the left sides of the vertebral bodies in that region.

A transitory asymmetry of the vertebral column must also be considered. This type of asymmetry has frequently been called physiological scoliosis and by definition is that form of lateral curvature of the spine which shows no bony changes and which disappears with recumbency. It is of interest because of the possibility of this type finally showing structural changes (Abbott, 1913; Smith, 1917; Girard, 1940). Of interest also are the reports that this transitory curve has its convexity directed toward the left in at least 70 per cent of the cases (Estes, 1920; Smith, 1927; Kuhns, 1938; Girard, 1940).

Although greater use of the right arm than of the left and pressure of the aorta are the two most frequent explanations given for the occurrence of lateral curvature, other factors have been considered to be contributory to this condition. These are age (Müller, 1933; Inman, 1943); longer leg length on one side (Allen, 1882); stronger action of the diaphragm on the left side (Jansen, 1910); peculiarities of the human gait (Farkas, 1941); and asymmetric standing (Bishop, 1859; Hellebrandt and Fries, 1942).

For the most part interest has been directed in the past toward an effort to determine the cause of lateral curvature rather than to actual measurements of the asymmetry or to an understanding of the alterations involved. Since the anteroposterior curves of the column, both primary and secondary, are contributed to by "wedging" of the bodies of the vertebrae it seemed suitable to examine this factor for a relationship with lateral curvature. This study is concerned with a com-

parison of bilateral heights of the vertebral bodies and of the intervertebral foramina first, in a series of vertebral columns which did not present apparent lateral curvature and second, in a series of columns which showed marked lateral curvature.

MATERIAL AND METHODS

The vertebral columns used for the study were from 70 cadavers. Between the time of embalming and their delivery to the laboratory they were stored in a phenol solution in tanks in the supine position; the time in the tanks varied from several months to two years. Thirty-six of the bodies had been embalmed with a solution of alcohol, carbolic acid, and glycerine. After these had been utilized by students of gross anatomy the vertebral columns were removed following disarticulation of the sacrum and ribs. For 34 bodies which had been embalmed in formalin the procedure was slightly different. The cadaver was placed in a prone position on the dissecting table. After the muscles of the back and gluteal region had been removed or reflected, sagittal saw cuts were made through the lower 10 pairs of ribs, about 3 inches lateral to the transverse processes of the vertebrae and through the ilia from the crests to the greater sciatic notches. A transverse cut was then made between the 2nd and 3rd pairs of ribs. The soft parts anterior to the column were removed and the column lifted out of the body. The sacrum and the ribs were then disarticulated from the vertebrae. Because a separation of each column used in the dissecting room had been made between the 3rd and 4th thoracic vertebrae as part of the routine dissecting procedure the upper limit of all of the columns studied was the 4th thoracic vertebra. Thus, in both groups observations were made on the lower 14 presacral vertebrae. A very limited amount of movement could be obtained in these columns with pressure but no change in their contours was observed during the process of preparation and measuring. The total number of columns examined was 70, of which 59 were males and 11 were females. Forty-two of the number were whites and 28 were Negroes. The ages ranged from 24 to 94 years.

For the first part of the investigation the ligaments and disks were left intact. The lower 13 pairs of intervertebral foramina were cleared of all soft tissue so that the bony notches were exposed. The greatest length of each foramen was determined by the following procedure. Both legs of a divider had superimposed on them transverse marks at corresponding levels. The divider, held at right angles to the foramen,

was inserted into each foramen until the transverse mark on the left leg corresponded with the superior notch. The legs of the divider were spread at the point of maximum vertical, or obliquely vertical, height and then set. The instrument was withdrawn and the distance between the outer borders of the legs at the level of the corresponding marks was measured, to .5 mm., by means of a calibrated sliding compass (Hermann).

A preliminary examination by inspection, after the sacrum and ribs had been disarticulated, provided an estimate of the presence and degree of lateral curvature. Of the 70 columns, 10 showed marked deviation; 5 presented a curvature to the right and 5 to the left. Deviation from the sagittal plane in the upper lumbar region was the criterion for the classification. These 10 columns were comprised of 5 white males, 2 white females, and 3 Negro males. The age of one was not known. The ages of the others ranged from 42 to 94 years, 6 of which were 79 years or older.

One column having no apparent deviation, representative of the larger group of columns, and one from each of the two smaller groups showing curvature was photographed. For this procedure each column was mounted on an inclined (about 40 degrees) surface and supported by means of a heavy wire which was attached to the posterior part of the base and extended several inches into the vertebral canal. Following the measuring of the foramina and the photography, the columns were skeletonized according to the method described by Terry (1932).

The second part of the procedure consisted of taking measurements of the individual vertebrae of each column. The vertical height of each body was measured on the right and left sides. The anterior and posterior midpoints of the superior surface were determined by inspection and marked. A point midway between these two, the midpoint of the superior surface of the body was located and marked. At a corresponding level marks were made on the right and left sides of the superior surface at the periphery of the body to indicate the points for measurement of the lateral vertical heights. Thus the superior surface of the body of each vertebra was marked at 5 points. The points in the midline were used only as guides for the placement of the right and left lateral points. Two vertical heights of each body were then measured with a spreading caliper (Hermann). In order to maintain as constant a relation as possible between the body of the vertebra and the measuring instrument, the caliper was mounted on a basestand, as re-

commended by Lanier (1939). The vertebra was held with its body in a horizontal plane; first the upper point of the caliper rested on the mark indicating the point for measurement of the right side, then the vertebra was moved so that the points of the caliper glided over the epiphyseal plate. The maximum height was recorded and the procedure repeated for the left side.

The measurements obtained for the lateral vertical heights of the bodies and for the foramen heights of 60 of the columns were grouped, for statistical study, according to age, race, and sex. The means, standard deviations, coefficients of variation, and their probable errors were calculated. The difference between any two means was considered to be of statistical significance only when the number was greater than 4 times the probable error of the difference.

OBSERVATIONS

The 60 columns (Fig. 1) were first separated according to age into two groups. One group (23 columns) ranged in age from 24 through 60 years and the other was made up of those over 60 years (37 columns). The measurements of the lateral heights of the vertebral bodies according to age and side are summarized in Table 1. The difference between the mean height of the right side and the mean height of the left side of each vertebral body is shown to be very small in the older as well as in the younger group. When the total mean height for the right side in the younger group is compared with the total mean height for the left side in that group it may be seen that the left exceeds the right by 1.6 mm. A similar comparison is made for the older group and again the left side exceeds the right, in this group by 1.2 mm. Finally the total mean height for the right side in the younger group may be compared with the total mean height for the right side in the older group; the difference is found to be 6.2 ± 3.3 mm. This comparison for the left sides of the two age groups shows a difference of 5.8 ± 3.3 mm. There is present a tendency for the left sides of the vertebrae to be longer than the right in both age groups and for the older group to exceed the younger in the length of both sides of the vertebral bodies. However, in no case is a difference shown, between means for an individual vertebra or between totals, that is statistically significant.

The measurements were next studied from the standpoint of race. This resulted in the comparison of a group of 34 whites with a group

TABLE 1

Means (mm.) of the lateral heights of the vertebral bodies, according to age and side[a]

Body	RIGHT			LEFT			
	M	*SD*	*CV*	*M*	*SD*	*CV*	Difference between means
			24-60 years (23 columns)				
T 4	18.3±.2	1.5±.2	8.1±.9	19.1±.2	1.3±.1	6.9±.7	—.8±.3
T 5	19.2±.2	1.2±.1	6.4±.7	19.1±.2	1.2±.1	6.1±.6	+.1±.3
T 6	19.7±.2	1.5±.2	7.8±.8	19.2±.2	1.6±.2	8.3±.8	+.5±.3
T 7	20.3±.2	1.3±.1	6.4±.6	20.0±.2	1.4±.1	6.8±.7	+.3±.3
T 8	20.5±.2	1.4±.1	6.8±.7	20.6±.2	1.3±.1	6.2±.6	—.1±.3
T 9	20.9±.2	1.4±.1	6.9±.7	21.1±.2	1.3±.1	6.3±.6	—.2±.3
T 10	21.7±.2	1.2±.1	5.6±.6	21.9±.2	1.5±.2	7.0±.7	—.2±.3
T 11	22.8±.2	1.5±.2	6.6±.7	22.8±.2	1.3±.1	5.5±.6	.0±.3
T 12	23.8±.2	1.6±.2	6.6±.7	23.9±.2	1.3±.1	5.6±.6	—.1±.3
L 1	25.3±.2	1.6±.2	6.4±.6	25.1±.3	1.8±.2	7.3±.7	+.2±.4
L 2	26.0±.3	1.8±.2	6.9±.7	25.8±.2	1.5±.2	5.9±.6	+.2±.3
L 3	26.9±.2	1.6±.2	6.1±.6	26.9±.2	1.5±.2	5.6±.6	.0±.3
L 4	27.3±.2	1.4±.1	5.1±.5	27.7±.2	1.7±.2	6.3±.6	—.4±.3
L 5	26.4±.2	1.1±.1	4.3±.4	26.4±.2	1.5±.2	5.8±.6	.0±.3
Total	315.6±2.2	15.9±1.6	5.0±.5	317.2±2.2	15.8±1.6	5.0±.5	—1.6±3.2
			Over 60 years (37 columns)				
T 4	18.5±.2	1.8±.2	10.0±.8	19.2±.2	1.8±.2	9.3±.8	—.7±.3
T 5	19.3±.2	1.4±.1	7.0±.6	19.6±.2	1.5±.1	7.6±.6	—.3±.2
T 6	20.5±.2	1.4±.1	7.0±.6	19.8±.2	1.5±.1	7.6±.6	+.7±.2
T 7	20.6±.2	1.8±.1	8.6±.7	20.3±.2	1.6±.1	7.9±.6	+.3±.3
T 8	21.2±.2	1.7±.1	7.9±.6	21.3±.2	1.7±.1	7.7±.6	—.1±.3
T 9	21.5±.2	1.4±.1	6.6±.5	21.8±.2	1.7±.1	7.7±.6	—.3±.3
T 10	22.5±.2	1.6±.1	7.1±.6	22.7±.2	1.9±.2	8.5±.7	—.2±.3
T 11	23.4±.2	1.7±.1	7.4±.6	23.4±.2	1.9±.2	8.2±.6	.0±.3
T 12	24.7±.2	2.1±.2	8.6±.7	24.7±.2	2.0±.2	8.0±.6	.0±.3
L 1	25.7±.4	3.1±.2	12.1±.0	25.7±.3	2.2±.2	8.6±.7	.0±.4
L 2	26.1±.2	2.2±.2	8.4±.7	26.2±.2	1.7±.1	6.5±.5	—.1±.3
L 3	27.1±.2	2.1±.2	7.8±.6	27.0±.2	1.8±.1	6.8±.5	+.1±.3
L 4	27.5±.3	2.3±.2	8.2±.6	27.7±.3	2.3±.2	8.4±.7	—.2±.4
L 5	26.5±.2	2.0±.2	7.5±.6	26.5±.3	2.4±.2	8.9±.7	.0±.4
Total	321.8±2.5	22.2±1.7	6.9±.5	323.0±2.4	21.8±1.7	6.7±.5	—1.2±3.5

[a] In this table (and in succeeding tables) the numerical difference between the means of the right and left sides is preceded by a + sign when the right side exceeds the left and by a — sign when the left side exceeds the right.

TABLE 2

Means (mm.) of the lateral heights of the vertebral bodies, according to race and side

	RIGHT			LEFT			
Body	*M*	*SD*	*CV*	*M*	*SD*	*CV*	Difference between means
			Whites (34 columns)				
T 4	18.8±.2	1.6±.1	8.6±.8	19.3±.2	1.8±.2	9.5±.8	−.5±.3
T 5	19.5±.1	1.1±.1	5.7±.5	19.6±.2	1.4±.1	7.0±.6	−.1±.2
T 6	20.4±.2	1.5±.1	7.4±.6	19.8±.2	1.4±.1	7.1±.6	+.6±.2
T 7	20.6±.2	1.8±.1	8.5±.7	19.3±.2	1.5±.1	7.7±.6	+1.3±.3
T 8	20.3±.2	1.5±.1	7.2±.6	21.3±.2	1.6±.1	7.6±.6	−1.0±.3
T 9	21.5±.2	1.4±.1	6.4±.5	21.8±.2	1.6±.1	7.5±.6	−.3±.3
T 10	22.5±.2	1.5±.1	6.5±.5	22.7±.2	1.9±.2	8.4±.7	−.2±.3
T 11	23.4±.2	1.7±.1	7.1±.6	23.5±.2	1.8±.2	7.7±.6	−.1±.3
T 12	25.0±.2	1.8±.1	7.1±.6	24.8±.2	1.7±.1	6.7±.6	+.2±.3
L 1	25.8±.7	3.2±.5	12.3±.0	25.6±.3	2.4±.2	9.4±.8	+.2±.8
L 2	26.4±.2	2.0±.2	7.5±.6	26.3±.2	1.5±.1	5.6±.5	+.1±.3
L 3	27.2±.2	1.9±.2	6.8±.6	27.1±.2	1.7±.1	6.1±.5	+.1±.3
L 4	27.6±.3	2.1±.2	7.8±.6	26.4±.3	2.4±.2	8.9±.7	+1.2±.4
L 5	26.6±.2	1.9±.2	7.3±.6	26.5±.3	2.2±.2	8.2±.7	+.1±.4
Total	326.2±2.3	20.2±1.7	6.2±.5	326.6±2.3	20.3±1.7	6.2±.5	−.4±3.3
			Negroes (26 columns)				
T 4	17.4±.2	1.6±.2	9.0±.9	18.5±.2	1.1±.1	5.9±.6	−1.1±.3
T 5	18.5±.2	1.3±.1	7.2±.7	18.9±.2	1.3±.1	6.7±.6	−.4±.3
T 6	19.5±.2	1.4±.1	7.2±.7	18.8±.2	1.6±.2	8.4±.8	+.7±.3
T 7	19.8±.2	1.2±.1	6.2±.6	19.6±.2	1.4±.1	7.4±.7	+.2±.3
T 8	19.9±.2	1.3±.1	6.5±.6	20.1±.2	1.2±.1	5.7±.5	−.2±.2
T 9	20.5±.2	1.4±.1	6.6±.6	20.7±.2	1.3±.1	6.2±.6	−.2±.3
T 10	21.4±.2	1.4±.1	6.3±.6	21.6±.2	1.5±.1	7.0±.7	−.2±.3
T 11	22.4±.2	1.5±.1	6.7±.6	22.3±.2	1.4±.1	6.0±.6	+.1±.3
T 12	23.0±.2	1.7±.2	7.4±.7	23.4±.2	1.6±.2	7.0±.7	−.4±.3
L 1	24.8±.2	1.6±.2	6.3±.6	24.7±.2	1.5±.1	6.0±.6	+.1±.3
L 2	25.2±.3	2.0±.2	7.8±.7	25.3±.2	1.7±.2	6.5±.6	−.1±.3
L 3	26.2±.3	1.9±.2	7.3±.7	26.3±.2	1.7±.2	6.3±.6	−.1±.3
L 4	26.8±.2	1.6±.2	6.0±.6	27.1±.3	1.9±.2	6.9±.6	−.3±.3
L 5	25.9±.2	1.3±.1	5.1±.5	26.0±.3	1.9±.2	7.5±.7	−.1±.3
Total	311.6±2.2	16.8±1.6	5.4±.5	312.5±2.2	16.8±1.6	4.9±.5	−.9±3.1

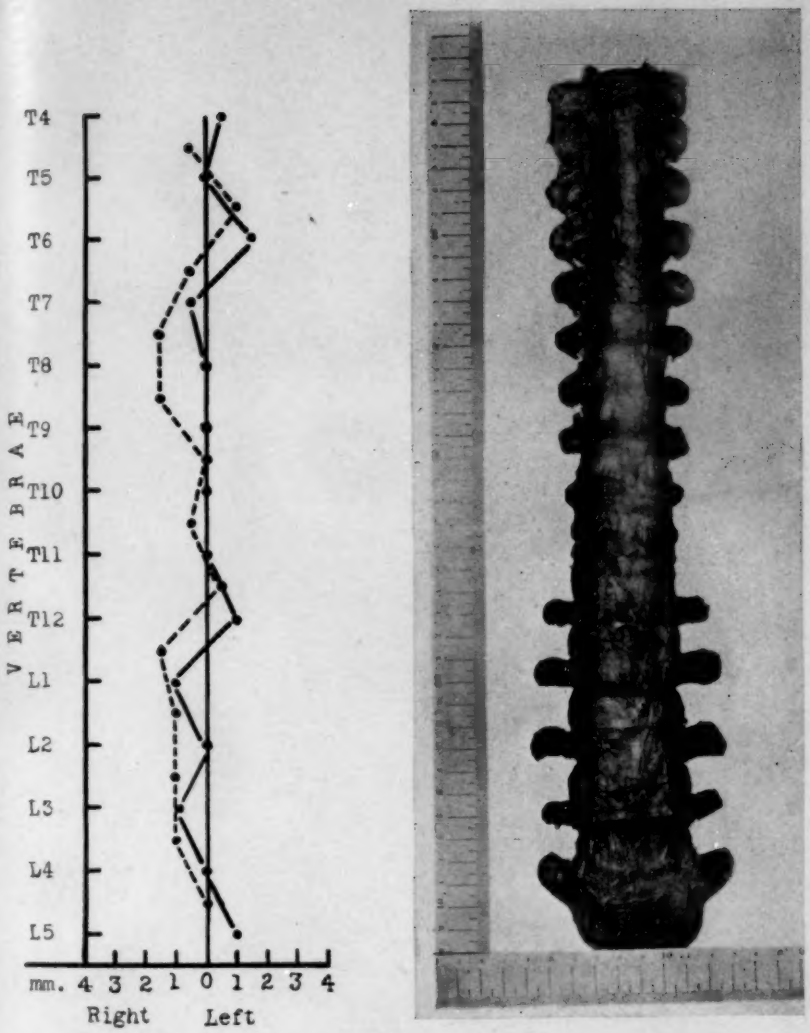

FIG. 1. VERTEBRAL COLUMN REPRESENTATIVE OF A LARGE PERCENTAGE OF COLUMNS STUDIED

The photograph at the right is representative of a large percentage of the vertebral columns examined. The graph at the left shows the difference in height between the right and left sides of the individual vertebrae and between the intervertebral foramina of the two sides for this particular column (white male, age 43 years).[2]

[2] In this and in succeeding figures the differences in the lateral heights of the bodies are shown by points connected by continuous lines; the differences in foramina heights by points connected by broken lines. In this figure, i. e. the right and left foramina between L 4, 5 are equal and the point is placed on the zero line; the left side of L 5 is 1 mm. higher than the right side so the point is placed 1 mm. to the left of the zero line.

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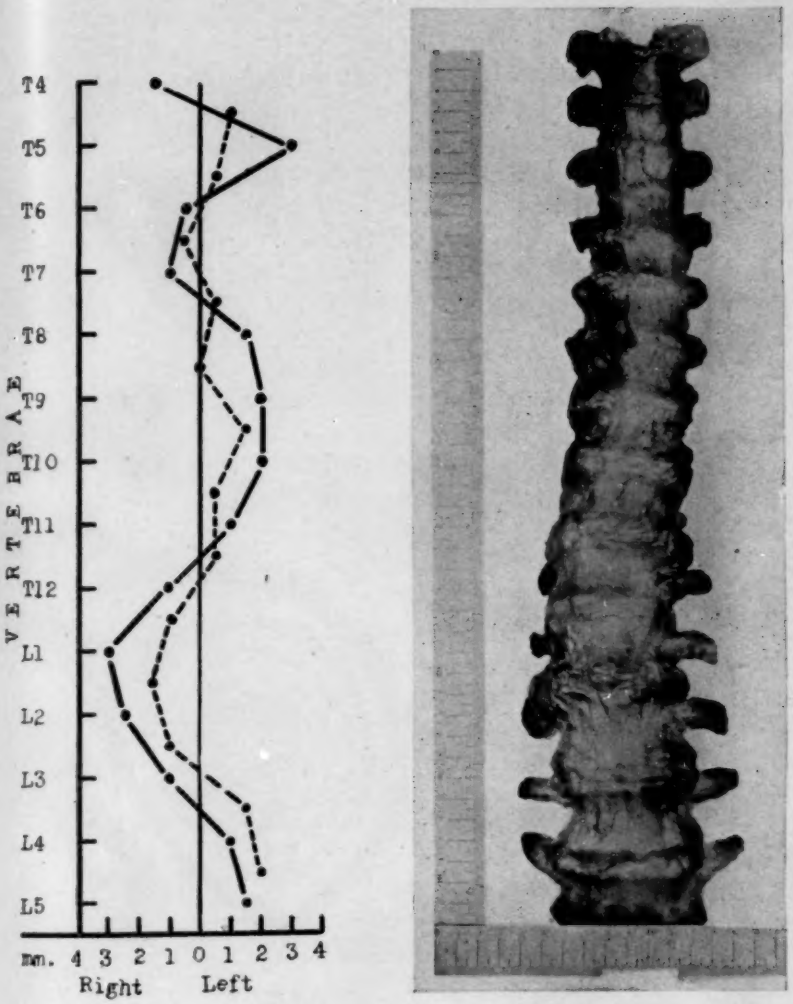

FIG. 2. ONE OF FIVE COLUMNS SHOWING CURVATURE TO THE RIGHT

The photograph at the right is of one of the five columns which showed curvature to the right (white male, age 79 years). The graph shows the difference in height between the right and left sides of the individual vertebrae and between the intervertebral formina of the two sides.

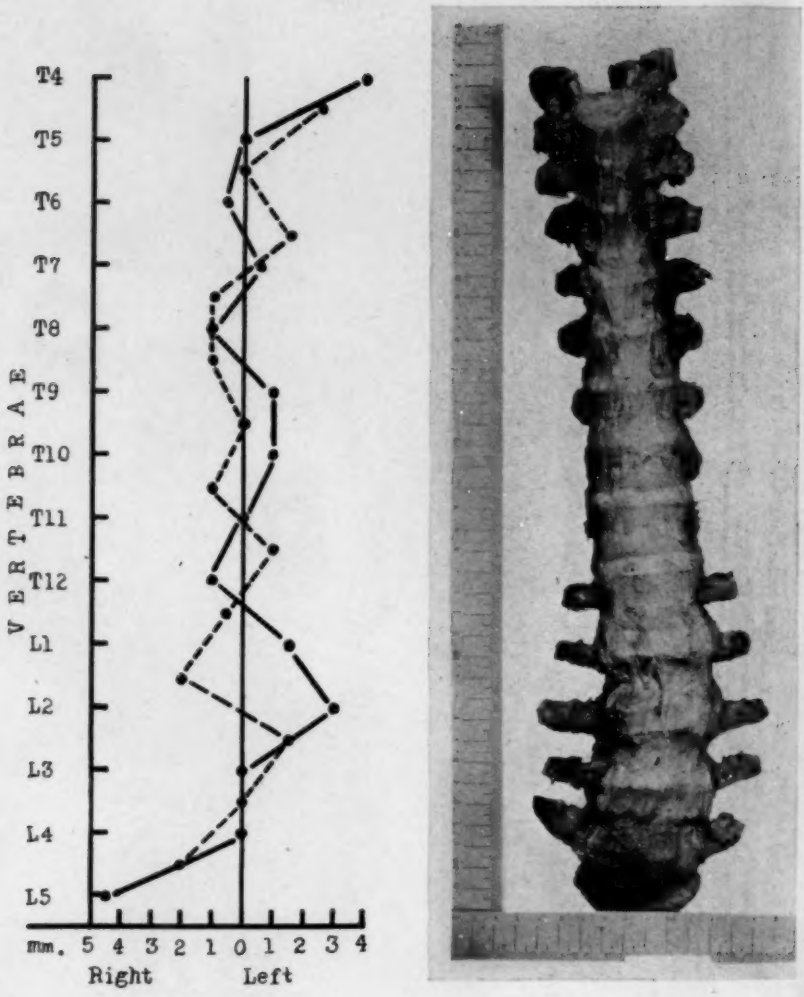

FIG. 3. ONE OF FIVE COLUMNS SHOWING CURVATURE TO THE LEFT

The photograph at the right is of one of the five columns which showed curvature to the left (white male, aged 88 years). The graph shows the difference in height between the right and left sides of the individual vertebrae and between the intervertebral foramina of the two sides.

of 26 Negroes. The data are shown in Table 2. Considering the mean heights of the right and left sides of individual vertebrae it can be seen that no significant difference is shown between the sides of any one vertebra in the Negro group but that in the white group T 7 shows a right side which is significantly longer than the left. The mean total height of the left side in the white group is .4 mm. longer than the mean total height of the right side in the same group but with a probable error of 3.3 mm.; this difference is not significant. In the Negro group the mean total height of the left side exceeds that of the right by .9 mm. with a probable error of 3.1 mm.; thus the difference between the total length of the two sides in the Negro group is not significant. When the total mean heights for the right sides of the vertebral bodies in the two races are compared the whites are found to exceed the Negroes by 14.6 ± 3.2 mm.; a similar comparison on the left side shows that the white race has a longer total mean height of 14.1 ± 3.2 mm. than the Negro race. These differences are greater than those found between the same sides of the two age groups and are sufficient to be of statistical significance. The difference between the lengths of the two sides within each racial group is small; the mean total length of the left side exceeds the mean total length of the right side in both groups.

The next arrangement of the columns was made according to sex (Table 3). In the group of 10 females there is no significant difference between the mean heights of the right and left sides of any particular vertebra but in the group of 50 males the 6th thoracic shows a significant difference (1.2 ± .2 mm.) between the heights of the two sides—the right side exceeding the left. Comparing the total mean height for the right sides of the vertebrae with the total mean height for the left side in the group of females the difference found is small (1.9 ± 3.4 mm.) and not significant. A similar comparison in the male group shows the right and left sides to differ by .7 ± 2.5 mm. If the total mean height for the right side in the female group is compared with the total mean height for the right side in the male group, the male group is found to exceed the female group by 25.1 ± 3.1 mm. Since this difference is 8.1 times its probable error it may be considered to be significant. The total mean heights for the left sides of the vertebral bodies of the two sexes show a difference of 23.9 ± 2.9 mm., thus, the difference is 8.2 times its probable error and therefore the total mean height of the left side in the male group is significantly longer than the total mean height of the female group. As would be expected the males exceed

TABLE 3

Means (mm.) of the lateral heights of the vertebral bodies, according to sex and side

Body	RIGHT			LEFT			
	M	*SD*	*CV*	*M*	*SD*	*CV*	Difference between means
			Females (10 columns)				
T 4	16.8±.3	1.4±.2	8.3±1.4	16.9±.4	1.7±.3	9.9±1.7	—.1±.5
T 5	17.9±.3	1.2±.2	6.6±1.0	17.7±.2	.7±.1	4.0± .6	+.2±.3
T 6	18.3±.2	1.1±.2	6.1± .9	17.9±.2	.8±.1	4.5± .7	+.4±.3
T 7	18.4±.4	1.7±.3	9.4±1.4	18.3±.3	1.2±.2	6.3±1.0	+.1±.4
T 8	19.0±.2	1.0±.2	5.4± .9	19.1±.2	.9±.1	4.8± .8	—.1±.3
T 9	19.6±.2	1.0±.2	5.3± .8	19.7±.2	.8±.1	4.1± .6	—.1±.3
T 10	20.3±.1	.6±.1	3.0± .5	20.5±.2	.9±.1	4.4± .7	—.2±.2
T 11	21.2±.2	1.1±.2	5.1± .8	21.1±.3	1.3±.2	6.3±1.0	+.1±.4
T 12	22.7±.2	1.1±.2	4.7± .7	22.9±.2	1.1±.2	4.9± .7	—.2±.3
L 1	23.2±.9	4.0±.6	17.2±2.6	23.6±.3	1.6±.2	6.6±1.0	—.4±.9
L 2	24.4±.3	1.2±.2	5.0± .8	24.6±.2	1.1±.2	4.5± .7	—.2±.4
L 3	25.6±.2	1.0±.2	4.1± .6	25.9±.2	1.0±.2	3.8± .6	—.3±.3
L 4	26.0±.3	1.6±.2	6.0± .9	26.5±.3	1.4±.2	5.2± .8	—.5±.5
L 5	26.1±.3	1.3±.2	5.0± .8	26.0±.3	1.5±.2	5.8± .9	+.1±.4
Total	298.8±2.5	11.9±1.8	4.0± .6	300.7±2.3	10.9±1.6	3.6± .5	—1.9±3.4
			Males (50 columns)				
T 4	18.5±.2	1.6±.1	8.8±.6	18.7±.1	1.3±.1	6.9±.5	—.2±.2
T 5	19.3±.2	1.2±.1	6.2±.4	19.5±.1	1.3±.1	6.7±.5	—.2±.2
T 6	20.3±.1	1.4±.1	6.7±.5	19.1±.2	1.5±.1	7.9±.5	+1.2±.2
T 7	20.6±.1	1.3±.1	6.3±.4	20.3±.1	1.3±.1	6.4±.4	+.3±.2
T 8	21.0±.1	1.5±.1	7.1±.5	21.1±.1	1.4±.1	6.8±.5	—.1±.2
T 9	21.4±.1	1.3±.1	6.2±.4	21.6±.1	1.5±.1	7.0±.5	—.2±.2
T 10	22.4±.1	1.4±.1	6.3±.4	22.6±.2	1.8±.1	7.8±.5	—.2±.2
T 11	23.0±.2	1.5±.1	6.6±.5	23.3±.2	1.5±.1	6.6±.5	—.3±.2
T 12	24.4±.2	2.0±.1	8.1±.6	24.5±.2	1.8±.1	7.3±.5	—.1±.3
L 1	25.8±.2	2.0±.1	7.9±.5	25.7±.2	1.9±.1	7.5±.5	+.1±.3
L 2	26.2±.2	2.0±.1	7.8±.5	26.1±.2	1.6±.1	6.1±.4	+.1±.3
L 3	27.0±.2	2.0±.1	7.4±.5	26.9±.2	1.8±.1	6.6±.4	+.1±.3
L 4	27.5±.2	1.9±.1	7.0±.5	27.8±.2	2.2±.2	7.8±.5	—.3±.3
L 5	26.3±.2	1.8±.1	6.8±.5	26.3±.2	2.2±.2	8.3±.6	.0±.3
Total	323.9±1.8	18.9±1.3	5.8±.4	324.6±1.8	18.5±1.2	5.7±.4	—.7±2.5

the females in bilateral heights of the individual vertebrae as well as in the bilateral heights of the total number of vertebrae measured. The difference between the heights of the right and left sides of the vertebrae are smaller within the groupings made according to sex than within either of the other two groupings which were made according to age and race.

In general, the lateral heights of the bodies of the 14 presacral vertebrae increased from above downward from the 4th thoracic through the 4th lumbar vertebra. The sides of the 5th lumbar were slightly less in height than those of the 4th. The difference between the total of the means of the right sides and the total of the means of the left sides, in all groupings, was very slight.

The heights of the intervertebral foramina were studied from the standpoint of sex (Table 4). The differences in mean height of the individual foramina (between right and left sides) and between their sums in both groups were slight and in no case of statistical significance. The difference between the total mean height for the right and for the left side in the females and the total mean height for the two sides in the males may be considered to be significant—the mean total height in the male group exceeds that in the female group; on the right side by 16.7 ± 3.0 mm. and on the left side by 20.7 ± 2.8 mm.

The series of columns which showed marked lateral curvature is too small to be studied statistically (Figs. 2 and 3). Table 5 presents the measurements for the two groups of columns and is so arranged that the mean height of each foramen may be compared with the sum of the mean heights of the two adjacent vertebral bodies (i. e. the height of the foramen between the 4th and 5th thoracic vertebrae can be compared with the sum of the lateral heights, on the same side, of the bodies of the 4th and 5th thoracic, etc.). The purpose of this is to determine the relationship of body heights to disk heights—assuming that the foramen will vary according to the thickness of the disk and thus that the height of the foramen may be taken as a relative measure of the thickness of the disk between adjacent vertebral bodies. A measure of correlation between body heights and disk heights was obtained by the Spearman rank-difference method; in the 5 columns showing curvature to the right the coefficient of correlation for the right side is + .81 and for the left side, + .84; in the 5 columns showing curvature to the left the coefficient of correlation for the right side is + .75 and for the left side, + .68. This shows a high positive correlation, especially

TABLE 4

Means (mm.) of foramen heights, according to sex and side

	RIGHT			LEFT			
Foramen	*M*	*SD*	*CV*	*M*	*SD*	*CV*	Difference between means
			Females (10 columns)				
T 4, 5	10.9±.2	.9±.2	8.4±1.4	11.6±.3	1.2±.2	10.5±1.9	—.7±.4
T 5, 6	11.8±.3	1.2±.2	9.9±1.5	12.7±.2	.9±.1	6.9±1.0	—.9±.3
T 6, 7	13.3±.3	1.2±.2	9.3±1.4	13.3±.2	1.1±.2	7.9±1.2	.0±.4
T 7, 8	13.8±.2	1.0±.2	7.3±1.1	13.8±.2	.9±.1	6.7±1.0	.0±.3
T 8, 9	13.6±.2	.9±.1	6.7±1.0	13.6±.1	.7±.1	4.9± .7	.0±.2
T 9, 10	13.2±.1	.6±.1	4.2± .6	13.7±.2	.8±.1	5.7± .9	—.5±.2
T 10, 11	13.3±.2	1.1±.2	8.5±1.3	13.2±.2	1.0±.2	7.8±1.2	+.1±.3
T 11, 12	14.3±.3	1.6±.2	11.2±1.7	14.5±.3	1.5±.2	10.3±1.6	—.2±.5
T 12, L 1	15.3±.4	1.7±.3	11.0±1.7	15.3±.3	1.4±.2	8.8±1.3	.0±.5
L 1, 2	16.5±.3	1.2±.2	7.1±1.1	16.4±.2	1.1±.2	7.0±1.1	+.1±.4
L 2, 3	17.5±.2	1.1±.2	6.0± .9	17.3±.3	1.4±.2	8.2±1.2	+.2±.4
L 3, 4	17.6±.4	1.7±.3	9.7±1.5	17.9±.3	1.2±.2	6.5±1.0	—.3±.4
L 4, 5	17.1±.4	2.0±.3	11.8±1.8	17.4±.4	1.9±.3	10.9±1.6	—.3±.6
Total	187.5±2.4	11.3±1.7	6.0±.9	191.1±1.8	8.5±1.3	4.4± .7	—3.6±3.0
			Males (50 columns)				
T 4, 5	12.3±.2	1.6±.1	12.7± .9	12.7±.2	1.6±.1	12.5± .9	—.4±.2
T 5, 6	13.4±.2	1.6±.1	12.2± .8	13.8±.2	1.9±.1	13.4± .9	—.4±.2
T 6, 7	14.5±.2	1.6±.1	11.1± .8	14.8±.2	1.8±.1	12.2± .8	—.3±.2
T 7, 8	15.4±.2	1.6±.1	10.5± .7	15.3±.2	1.8±.1	11.6± .8	+.1±.2
T 8, 9	15.0±.2	1.6±.1	10.6± .7	15.4±.2	1.8±.1	11.4± .8	—.4±.2
T 9, 10	14.4±.2	1.7±.1	11.5± .8	14.6±.2	1.7±.1	11.5± .8	—.2±.2
T 10, 11	14.3±.2	1.7±.1	11.9± .8	14.5±.2	1.7±.1	11.4± .8	—.2±.2
T 11, 12	15.1±.2	1.8±.1	11.8∓ .8	15.3±.2	1.8±.1	11.6± .8	—.2±.2
T 12, L 1	16.7±.2	1.8±.1	10.6± .7	17.0±.2	1.7±.1	10.0± .7	—.3±.2
L 1, 2	18.2±.2	1.8±.1	9.8± .7	18.0±.2	1.8±.1	9.9± .7	+.2±.2
L 2, 3	19.1±.2	2.0±.1	10.6± .7	19.2±.2	2.0±.1	10.2± .7	—.1±.3
L 3, 4	18.7±.2	2.2±.2	11.5± .8	18.9±.2	2.3±.2	12.0± .8	—.2±.3
L 4, 5	17.2±.3	2.7±.2	15.7±1.1	18.0±.2	2.3±.2	13.0± .9	—.8±.3
Total	204.2±1.8	18.4±1.2	9.0± .6	211.8±2.1	22.3±1.5	10.5± .7	—7.6±2.8

TABLE 5

Means (mm.) of intervertebral foramen heights and of adjacent body heights according to direction of lateral curvature

(The differences in height of the two sides is also given for both foramina and bodies and are recorded in the column to indicate which side is longer.)

	RIGHT		LEFT		DIFFERENCES IN FORAMINA		DIFFERENCES IN BODIES	
	Foramen	Adjacent bodies	Foramen	Adjacent bodies	Right	Left	Right	Left
Five columns showing principal curvature to the right								
T 4, 5	11.9	38.2	13.0	39.3	—	1.1	—	1.1
T 5, 6	13.3	41.4	14.2	39.2	—	.9	2.2	—
T 6, 7	15.4	42.6	14.3	39.2	1.1	—	2.7	—
T 7, 8	15.3	42.1	15.0	42.0	.3	—	.1	—
T 8, 9	15.1	43.0	14.7	43.7	.4	—	—	.7
T 9, 10	12.5	43.7	13.9	45.5	—	1.4	—	1.8
T 10, 11	13.4	45.2	14.0	47.1	—	.6	—	1.9
T 11, 12	14.6	47.3	15.8	47.8	—	1.2	—	.5
T 12, L 1	15.6	50.3	16.3	49.4	—	.7	.9	—
L 1, 2	17.6	54.4	17.5	51.4	.1	—	3.0	—
L 2, 3	20.2	57.3	18.1	53.8	2.1	—	3.5	—
L 3, 4	19.3	57.1	19.2	56.8	.1	—	.3	—
L 4, 5	17.5	55.0	19.2	57.3	—	1.7	—	2.3
Five columns showing principal curvature to the left								
T 4, 5	12.8	38.2	14.0	37.2	—	1.2	1.0	—
T 5, 6	13.6	40.0	13.9	39.1	—	.3	.9	—
T 6, 7	15.1	38.1	14.9	38.8	.2	—	—	.7
T 7, 8	15.8	39.7	15.5	40.0	.3	—	—	.3
T 8, 9	14.4	43.2	14.5	42.8	—	.1	.4	—
T 9, 10	14.2	43.0	13.8	43.4	.4	—	—	.4
T 10, 11	14.8	43.5	14.2	43.2	.6	—	.3	—
T 11, 12	15.1	46.0	15.0	45.2	.1	—	.8	—
T 12, L 1	15.9	44.8	15.5	48.0	.4	—	—	3.2
L 1, 2	16.2	46.5	16.7	51.3	—	.5	—	4.8
L 2, 3	17.4	51.6	18.4	54.1	—	1.0	—	2.5
L 3, 4	16.7	52.5	17.2	55.0	—	.5	—	2.5
L 4, 5	16.1	54.3	15.0	53.5	1.1	—	.8	—

in the columns with curvature to the right. Whereas the heights of the foramina in these cases vary directly with the heights of the bodies (showing a tendency for the disks to increase the curvature) it must be remembered that the number of cases is small, the variation large, and the measure of correlation crude.

DISCUSSION

A large percentage of the vertebral columns freshly removed from cadavers showed very little or no lateral curvature.

After the columns were skeletonized and the heights of the vertebrae measured, the inequalities of the right and left sides of the vertebrae were studied. The outstanding characteristics were the small differences between the heights of the two sides, usually not more than 2 millimeters, and the tendency for the bodies to be higher on the same side through several consecutive vertebrae and then to be equal or higher on the opposite side for the succeeding vertebrae. This shift took place most frequently between series of 2 or 3 vertebrae but often it occurred between alternate vertebrae or the series extended to 4 or 5 without being interrupted by a body whose side heights were equal or one with inequality to the opposite side.

Objective measurements for comparison were not found. Asymmetry of the bodies was reported by Humphry (1858) who observed that a deficiency in height of one body is compensated for immediately by the vertebral body above, below, or both above and below, so that the "proper line of the column is preserved." Anderson (1883) measured the lateral sides of the vertebral bodies and found that the right sides of the bodies are greater than the left, from the 7th to the 10th thoracic vertebra, and that the left sides of the bodies are sometimes higher in the upper thoracic region. Figures for the heights were not given. Jansen (1910) describing the findings of Péré,[4] stated that of 100 apparently normal cadavers examined 93 showed lateral deviation, of which 79 had curvature to the right and 14 to the left in the middle part of the thoracic region. Furthermore 41 of the 79 had 3 characteristic curves which had apices as follows: T 2 and 3, with convexity to the left; T 5 and 6, with convexity to the right; T 11 and 12, with convexity to the left. The only statement concerning his method is

[4] Péré, 1890. Les courbures laterales normales du rhachis humain. *Paris.*

that "the anterior surfaces of the vertebral columns were examined in a most careful manner."

Farkas (1941) was interested in lateral curvature and measurements of the individual vertebrae. His method for determining the direction of the curvature was that of observation of the dried bones hung on a wire. He found that the lateral curve was convex to the right in one segment (T 7 through L 1) and convex to the left above and below that region. Furthermore, he found a slight amount of lateral wedging of the bodies but since the higher side was not always found on the convex side of the column he concluded that the inequality in the heights of the bodies is not an important factor in the formation of the curvature. Data on the lateral heights were not presented.

Using bony measurements as an indication of curvature, as was done by Turner (1886) and Trotter (1929), it may be stated that male columns show a tendency to have slight lateral curvature in the thoracic region whereas female columns are straight. According to Trotter (1929), male columns show more sagittal plane curvature than do female columns. This is interesting because it is the opinion of Steindler (1935) that "kyphosis is a condition which counteracts and not facilitates lateral curvature." If it is true that increased deviation in the sagittal plane means that coronal plane curvatures are less likely to occur, the tendency to show lateral curvature of the vertebral column should be greater in females, other factors being equal, than in males. According to this study, however, the vertebral columns of males have a greater tendency to show lateral curvature than do those of females.

Heights of intervertebral foramina, according to the means obtained in this study, do not increase in size regularly from above downward, as Grant (1940) and Jamieson (1943) have stated, but rather they increase from the foramen between T 4 and 5 through that between T 7 and 8, are then smaller for several foramina, increase in size again as far as the foramen between L 3 and 4 or L 4 and 5 and then are somewhat smaller.

The value of the observations on the columns which showed marked lateral curvature is in their interest rather than their significance. A question that is frequently discussed is the relative parts played by the vertebral bodies and the intervertebral disks in curvature of the column. Todd and Pyle (1928) believed that great variability in the curvature is possible without a change in vertebral body dimensions. They were interested in anteroposterior curves but this may also be

true in lateral curves. Since the curves in this series were exaggerated it was felt that whatever conditions exist normally might show more clearly in these. The assumption was made that foramen heights may be taken as an indirect measurement of the thickness of the intervertebral disks. The measure of correlation obtained showed that the disks tend to increase the curvature rather than to compensate for changes in body heights. Whether or not this finding will be substantiated by study of a statistically significant number of columns with marked lateral curvature there still remains the question of which change precedes the other, i. e. the lengthening or shortening of the disk or of the vertebral body. In the cadaver which Lane (1887) described, showing lateral curvature, the disks were not compressed.

The age of this group of columns tended to be old. Six of the 9 whose ages were known were 79 years or older. This is interesting because Müller (1933) in a clinical paper on dislocation of the lumbar vertebrae refers to the scoliosis of old age and Inman (1943) has described briefly a condition of lumbar scoliosis which he says "constitutes the scoliosis of old age."

That asymmetry can be demonstrated in the vertebral bodies seems certain. Agreement as to the degree, effect on lateral curvature and on the location of the curvature when present is not so universal. If the bodies are of equal height on the two sides early in life, as Farkas (1941) believes, some factor must become active as age advances that changes that condition. Explanations for the occurrence of these inequalities were mentioned in the introductory paragraphs. They are of passing interest because of the differences of opinion.

A major problem has been that of finding a satisfactory method of determining, in any given vertebral column, either the exact extent or the direction of a lateral deviation. It is believed that some measure of it has been obtained in this study from a comparison of the lateral vertical heights of the right and left sides of the vertebral bodies. The number of variations between the right and left sides in each column was great but the degree of variation was small and no pattern of variation, followed by a large percentage of the 60 columns which presented no apparent lateral curvature, could be made out. From a study of the means of these measurements the conclusion may be drawn that the columns which appeared to have no lateral curvature, in the preliminary examination, showed very little difference between the two sides. An exception to this generalization is that the 6th thoracic

vertebra (in males) had a significantly greater height on the right side—a factor which probably contributes to the slight curve which anatomists have described as being present in the thoracic region of the typical vertebral column.

The influence of torsion of the vertebrae has not been considered in this study.

SUMMARY

Observations were made on 70 vertebral columns taken from cadavers. Sixty of the columns were considered to be essentially straight; the remaining were classified as showing marked coronal plane deviation.

The data on 60 columns were studied statistically to determine whether or not a significant difference could be demonstrated between the body heights or between the intervertebral foramen heights of the right and left sides. Groupings were made according to age, race, and sex.

The only vertebra in which a significant difference was found between the mean heights of the right and left sides was the 6th thoracic, in the group of 50 males, where the right side showed a greater height.

No significant difference was present between the mean heights of the intervertebral foramina of the two sides.

The heights of the sides of the bodies increased from above downward as far as the 5th lumbar whose heights were less than those of the 4th.

The heights of the intervertebral foramina increased from above downward except at the level of the 8th and 9th or 9th and 10th thoracic, and at the level between lumbar 4 and 5 where decreases were shown.

In the 10 columns which showed marked curvature the heights of the foramina and the lateral heights of the bodies varied directly, the correlation being slightly higher in the 5 which showed the principal deviation to the right. The heights of the foramina and the lateral heights of the bodies in these columns were greater on the side with the convexity of the curve and less on the opposite side at the same level where the curve was concave. The ages of 6 of the 9, whose ages were known, were 79 years or older.

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A COMPARISON OF THE FREQUENCIES OF CERTAIN GENETIC TRAITS AMONG GENTILE AND JEWISH STUDENTS

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FOR the past year genetic data have been obtained from all students in elementary genetics at Ohio State University. These data include the blood groups, blood types, Rh blood antigen, ability to taste phenyl-thio-carbamide, dermatoglyphics, functional handedness and racial origin. We now have such data from 343 individuals. The objective of this project is to obtain an estimate of the gene frequencies of these traits among populations of different racial origins.

On the basis of racial origin these 343 students fall into several groups, including Scandinavian, Slavic, Anglo-Saxon, Latin, Greek, Syrian, Chinese, Russian and Negro. Several are of mixed parentage, and many, such as the Negroes, Greeks and Chinese do not form large enough groups for valid comparisons.

When classed as to whether Jewish or Gentile, however, two surprisingly well-defined groups appear. Eighty-four students listed themselves as Jews. Fifty-six or approximately two-thirds of these are of Russian descent. Twenty-one are of Roumanian, Polish and Hungarian descent, and only seven of the entire group are of English, German and French descent. The Jewish population is essentially of Russian and Central European origin.

The Gentile population is essentially of Anglo-Saxon and western European origin. Only six Gentile students listed themselves as being of Russian or Central European origin, and these were eliminated from the Gentile group, as were also the Greeks, Italians, Negroes and Chinese. This leaves a Gentile population of fairly homogeneous origin. Two hundred and forty-one** are included in this group, of which

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** Some neglected to give certain data, accounting for less than 241 in some Gentile groups.

129 (54.4 percent) traced their parentage to inhabitants of the British Isles, 79 (33 percent) are of German descent, while the remainder are of Scandinavian, Dutch and French descent. The Jewish and Gentile populations thus come from somewhat different parts of Europe. It is hoped that after a period of years sufficient numbers will be available in other groups, such as Negroes and Chinese, to make comparisons such as we shall now give between Gentiles and Jews.

BLOOD GROUPS

Table 1 shows the percentages of each of the four blood groups and the frequencies of the genes p, q, and r, not only among the Gentile and Jewish students, but also the findings of other investigators[1] for an unselected United States population, Russian Jews in Odessa, and unselected inhabitants of Odessa. The Jewish students and the Russian Jews show striking similarities, much more than do the two student groups. The Gentile students show greater similarities to the unselected North Americans than to any other group. The greatest differences are shown between unselected Russians and unselected Americans. Of the four blood groups, O shows the greatest variability, Jewish students showing 10.5 percent less of blood group O than do North American whites, a significant amount. The gene frequencies of the Jewish students vary significantly from those of the unselected North Americans, while the Gentile students differ significantly from both the Russian Jews, and the unselected Russians. These results indicate that the blood group distributions are more similar among Russian and American Jews, than among American Jews and American Gentiles, or among Russian Jews and Russian Gentiles. Unselected Americans and unselected Russians are the least similar of all.

BLOOD TYPES

Table 2 shows the distributions of the M and N blood antigens among the Jewish and the Gentile students, as well as among an unselected North American white population.[1] The Jewish population deviates from the Gentile in having a higher percentage of antigen M and a lower percentage of antigen N. It deviates even more from the larger unselected population. The difference between the two student populations is significant, giving a Chi-square of 7.11, with two degrees of freedom. The Gentile population does not deviate significantly from

TABLE 1

Percentages of the blood groups and frequencies of the blood group genes in various populations

POPULATION	INVESTIGATOR	NUMBER	PERCENT OF GROUP				GENE FREQUENCIES		
			O	A	B	AB	p	q	r
United States, unselected	Snyder	20,000	45.0	41.0	10.0	4.0	25.9	7.3	67.0
Gentile students	Rife and Schonfeld	237	41.1	44.4	12.7	1.6	28.3	9.2	64.1
Jewish students	Rife and Schonfeld	84	34.5	45.2	11.0	8.3	30.5	8.0	58.7
Russian Jews in Odessa	Barinstein	1,475	36.6	41.7	15.6	6.1	27.8	11.5	60.5
Unselected Russians, Odessa	Leitschik	1,831	31.8	46.2	17.4	4.6	29.8	11.9	56.5

the unselected population. Jewish students are thus characterized by a lower frequency of gene m and a higher frequency of gene M than are Gentile students.

TABLE 2

Percentages of the M and N blood types and frequencies of the genes M and m in different populations

POPULATION	INVESTIGATOR	NUMBER	PERCENT OF TYPES			GENE FREQUENCIES	
			M	N	MN	M	m
United States unselected	Landsteiner-Levine, Wiener, Herman-Derby, Hyman	6,129	29.16	21.26	49.58	55.0	45.0
Gentile students	Rife and Schonfeld	237	26.5	16.8	56.5	54.7	45.3
Jewish students	Rife and Schonfeld	84	38.1	9.5	52.3	64.2	35.8

Rh AGGLUTINOGEN

Table 3 shows the frequencies of the Rh agglutinogen among the Gentile and Jewish students. During the first two quarters blood was not tested for the Rh agglutinogen, which accounts for the smaller numbers of students. The differences between the populations are of no significance although there is a suggestion of a higher frequency of the Rh agglutinogen among the Jewish students. The general North American white population shows about 85 percent Rh-positive.[6]

TABLE 3

Percentages of individuals showing Rh agglutinogen in Gentile and Jewish student groups

GROUP	NUMBER	Rh POSITIVE	Rh NEGATIVE
Gentiles	112	82.61	17.39
Jews	40	90.00	10.00

TASTE REACTION

Table 4 shows the percentages of tasters among Gentile and Jewish students and among unselected North American whites. While Jewish students showed a higher percentage of tasters, the difference is too small to be of statistical significance. Both student groups show significantly higher percentages of tasters than did the unselected group.[5] It seems likely that these differences may be due to more refined techniques used in testing the students. Without such techniques, an occasional taster may be recorded as a non-taster.

TABLE 4

Percentages of tasters and non-tasters of phenyl-thio-carbamide among Gentile and Jewish students, and unselected whites in the United States

GROUP	NUMBER	TASTERS	NON-TASTERS
Unselected	3643	70.2	29.8
Gentiles	232	79.7	20.3
Jews	82	85.3	14.7

DERMATOGLYPHICS

Table 5 shows the percentages of patterns on each of the five palmar areas and of whorls on finger-tips among Gentile and Jewish students, and also among 200 Jews in New Orleans,[3] and 300 unselected North American whites.[2] The two Jewish populations show marked similarities, as do the Gentile and unselected populations. Jewish and non-Jewish populations showed striking differences. In general, the Jewish populations show much higher pattern frequencies. This is most marked in the percentages of whorls, the Jews showing whorls on approximately 40 percent of finger-tips, and the Gentiles on approximately 25 percent of finger-tips. These differences are highly significant. Jews also show higher pattern frequencies on thenar/first, second and third inter-digital areas. No significant differences are found between Jews and non-Jews on hypothenar and fourth inter-digital areas. These observations indicate that Jews from different sections of the United States are much more similar in respect to dermatoglyphics than are Jews and Gentiles from the same section. Genes responsible for palm and

TABLE 5

Comparison of the frequencies of patterns on palms and whorls on finger tips in different populations
(In percentages.)

POPULATION	INVESTIGATOR	NUMBER	HYPOTHENAR	THENAR-FIRST INTERDIGITAL	SECOND INTERDIGITAL	THIRD INTERDIGITAL	FOURTH INTERDIGITAL	WHORLS ON FINGER TIPS
Unselected European Americans	Cummins	300	37.2	5.5	4.2	40.8	49.0	25.7
Gentile students	Rife and Schonfeld	237	36.3	10.7	5.9	33.4	58.9	25.2
Jewish students	Rife and Schonfeld	84	38.0	16.0	8.9	53.0	56.5	39.7
New Orleans Jews	Cummins and Midlo	200	40.5	17.7	9.0	52.7	54.0	42.7

finger patterns thus appear to have much higher frequencies among Jews than among white Gentile populations in the United States.

HANDEDNESS

In this investigation handedness refers to the preferred hand in one-handed operations. The following criteria were used in the determination of handedness: the hand used for throwing, writing, sewing, bowling, hammering, sawing, shooting marbles, striking a match, scissors, cutting with a knife, use of a fork, and the students' own testimony as to handedness. Those preferring the left hand for one or more of these operations were classed as left-handed, while the remainder were classed as right-handed. Table 6 shows the comparisons. Left-handedness occurs about twice as frequently among the Jewish as among the Gentile students. As shown by the Chi-square, the results are significant, indicating higher frequencies of the gene or genes for left-handedness among Jewish than among Gentile populations.

TABLE 6

Frequencies of right and left-handedness among Gentile and Jewish students

GROUP	RIGHT-HANDERS	LEFT-HANDERS	TOTAL
Gentile students	219	22	241
Jewish students	68	16	84

$\chi^2 = 5.95$. 1 d.f.

HANDEDNESS AND DERMATOGLYPHICS

The tests for handedness were, of course, less objective and less satisfactory than those for the other traits investigated. It has been shown (Cromwell and Rife, 1942) that left-handers show less bilateral asymmetry in their dermatoglyphics than do right handers. This gives us a means of checking on the validity of the diagnosis of handedness by the criteria we have previously mentioned.

The reduction in bilateral asymmetry among left-handed populations is much more marked among females than among males. Table 7 shows the student groups classed both as to sex and handedness, and

TABLE 7

Percentages of whorls on finger-tips of right and left hands of Gentile and Jewish students, grouped as to sex and handedness

POPULATION	NUMBER	RIGHT HANDS	LEFT HANDS	BOTH
Gentile females, right-handed	156	27.0	23.0	25.0
Gentile females, left-handed	16	23.7	26.2	25.0
Gentile males, right-handed	63	32.6	19.4	26.0
Gentile males, left-handed	6	26.6	16.6	21.6
Jewish females, right-handed	42	37.1	33.8	35.5
Jewish females, left-handed	11	47.3	45.4	46.3
Jewish males, right-handed	26	58.1	47.2	52.6
Jewish males, left-handed	5	52.0	20.0	36.0

the numbers and percentages of whorls on right and left hands of each group. Note the reduction in bilateral asymmetry in the number of whorls among left-handed as contrasted with right-handed females.

A more delicate test for reduction in bilateral asymmetry can be made by comparing the number of inferior patterns among right-handed and left-handed female groups. (Cromwell and Rife, 1942). Patterns occur more frequently on the thenar-first and fourth interdigital areas of left hands, and on the second and third inter-digital areas of right

hands. Whorls occur more frequently on right than on left ring fingers. A reversal of this general tendency is more likely to occur among left-handers than in right-handers, notably among females. When a pattern occurs on only one hand, and on the reverse hand from usual, it is termed an inferior pattern. Thus, a whorl on the left ring finger, if none is present on the right ring finger, is termed an inferior pattern, as would be a thenar pattern on the right hand only. Each individual thus has five areas in which inferior patterns occur. Left-handed female populations show significantly more inferior patterns than do right-handed females.

TABLE 8

Numbers of inferior patterns among Gentile and Jewish females, grouped as to handedness

POPULATION	NUMBER	THENAR-FIRST INTERDIGITAL	SECOND INTERDIGITAL	THIRD INTERDIGITAL	FOURTH INTERDIGITAL	WHORLS ON RING FINGER	TOTAL NUMBER	PERCENT
Gentile students, right-handed	156	1	2	8	12	12	35	4.6
Gentile students, left-handed	16	1	1	1	3	1	7	8.7
Jewish students, right-handed	42	0	0	2	3	4	9	4.2
Jewish students, left-handed	11	0	0	1	3	1	5	11.3

Table 8 shows such a comparison among female Jewish and Gentile students. In both groups inferior patterns occur more frequently among the left-handers. The difference between the right and left handers is statistically significant, giving a Chi-square value of 5.79. Thus the dermatoglyphics give confirmatory evidence that the populations were correctly diagnosed as to handedness.

SUMMARY

A population of 241 Gentile students, principally of British and Northwestern European ancestry, were compared with a population

of 84 Jewish students, principally of Russian descent, in respect to the occurence of the four blood groups, the M and N antigens, the Rh antigen, ability to taste phenyl-thio-carbamide, the frequencies of patterns on palms and whorls on finger-tips and functional handedness.

The Jewish students showed a lower frequency of blood group O than did the Gentile students. When compared with the results of other investigators, the Jewish students show a closer resemblance to Russian Jews than to Gentile students or to unselected North American whites.

The Jewish students show a significantly higher frequency of antigen M and a lower frequency of antigen N than do the Gentile students.

No significant differences are shown between the two populations in respect to the occurrence of the Rh agglutinogen or the percentages of tasters of phenyl-thio-carbamide.

Patterns occur on palms, and whorls on finger-tips, with much greater frequencies among the Jewish students than among the Gentile students. The results correspond very closely with the results of other investigations which compared New Orleans Jews with unselected whites. An examination of the blood group frequencies and dermatoglyphic features indicate similar gene frequencies for Jews in various sections of the United States and Russia.

Left-handedness occurs almost twice as frequently among the Jewish as among the Gentile students. This observation is confirmed by comparisons of the dermatoglyphics.

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PREVALENCE OF PULMONARY TUBERCULOSIS AMONG SELECTEES[1]

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THE presented findings on pulmonary tuberculosis relate to selectees examined at the Joint Army and Navy induction stations during February, 1943. The findings are presented here without any attempt to correlate these with any other studies on tuberculosis.

SOURCE OF DATA

D. S. S. Form 221. As required by the Mobilization Regulations (MR 1-9, Section XIII), each selectee is to be given, upon induction into the Armed Forces, a chest examination consisting of a roentgenogram and other usual methods of physical diagnosis. A pertinent history of the past chest diseases is also to be taken. The findings from these examinations are recorded by the examining physician on D. S. S. Form 221 ("Report of Physical Examination and Induction") filled out for each selectee. Copies of these reports on all selectees examined at the Joint Army and Navy induction stations, except those inducted into the Navy, Marine Corps, and Coast Guard, are received and processed by the Office of The Surgeon General of the Army.

Sample used. A random sample was chosen from these reports for February, 1943, comprising 21,131 forms on white selectees and 2,566 on colored selectees. The present findings are based on these forms, with an adjustment for the selectees inducted into the Navy, Marine Corps, and Coast Guard.

CLASSIFICATION OF DIAGNOSES

The purpose of the chest examinations given at the induction stations is to determine whether or not the examined selectee is fit for service

[1] From the Medical Statistics Division, Surgeon General's Office, Army Service Forces.

in the Armed Forces. Consequently, in making the diagnosis the physician is mainly guided by the provisions outlined in detail in the above-mentioned MR 1-9 (Section XIII) Oct. 15, 1942. This is especially true with respect to arrested cases of tuberculosis. For calcified tuberculosis lesions, for instance, certain arbitary limits were set up, based upon the size of the lesions or their number, or both.[2]

The diagnoses as reported on the forms were classified as follows: *Negative, Arrested-Acceptable, Positive.*

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[2] The following provisions were set up by the MR 1-9 for arrested cases of pulmonary tuberculosis acceptable for general service:

"Healed intrathoracic primary tuberculosis lesions, demonstrable in roentgenograms, but of slight extent. The following specifications of the limits of such lesions are intended to exclude persons with disease which is most likely to be in part caseous and therefore potentially hazardous. The limits are set arbitrarily to provide an objective basis on which the examiner may render a decision. All measurements refer to single, standard 14- by 17-inch direct projection roentgenograms. These lesions may consist of—

(1) Calcified residues of lesions of the intrathoracic lymph nodes, provided none of these exceeds an arbitrary limit of 1.5 cm in diameter and the total number of such lesions does not exceed five.

(2) Calcified lesions of the pulmonary parenchyma, provided the total number of these does not exceed ten. One of these may equal but not exceed 1 cm in diameter, but none of the remainder may exceed 0.5 cm in diameter. In the roentgenogram such calcified lesions should appear isolated, sharply circumscribed, homogeneous, and dense.

The above arbitrary limits of calcified lesions are set on the assumption that large and numerous lesions are more likely to be partially unhealed, and therefore a potential source of future recrudescence, than small lesions of limited distribution. It is recognized, however, that in some individuals calcified tuberculosis lesions exceeding these limits may be present which are so well healed that the possibility of future reactivation is remote. Further consideration may be given to the acceptability of persons with calcified lesions of this type when the state of health in all other respects clearly warrants the opinion that the lesions in question are healed. In such cases the history of the applicant and his age, as well as the character of the lesions as seen in X-ray films, provide criteria for estimating the probability of complete arrest of the tuberculous process. If there is no history of active tuberculosis or symptoms which might be interpreted as evidence of this disease and if the applicant is more than 25 years of age, and if finally the calcified lesions seen are dense and discrete in character and not hazy or irregular in outline, such lesions may be considered as not prejudicial to future health. In these cases the applicant may be accepted provided the report of physical examination and the chest X-ray films have been reviewed and acceptance has been recommended by a medical examiner specially qualified in the diagnosis of diseases of the chest," (MR 1-9, Change 1, par. 56f).

Negative. This category refers to cases where the X-ray films and any additional diagnoses were interpreted by the examining physicians as manifesting *no* evidence of pulmonary tuberculosis.

Arrested-acceptable. This category includes cases of arrested pulmonary tuberculosis where the inactive tuberculous lesions were diagnosed as non-disqualifying defects for the service, according to the provisions of MR 1-9. (See footnote 2.)

Positive. This category includes (a) cases diagnosed as active pulmonary tuberculosis, (b) cases of arrested tuberculosis—not acceptable for the service under MR 1-9, and (c) a negligible proportion of "doubtfully-positive" cases, the latter class referring to cases which would be acceptable for service after a re-examination has proved "stability."

FINDINGS

White selectees: Variations by age. The findings on the prevalence of pulmonary tuberculosis among white selectees examined at the induction stations are presented in Table 1. The relative frequencies, to a base of 1,000 selectees, are given for separate age groups.

It is evident from these findings that there was essentially no pronounced variations in the prevalence of tuberculosis among white selectees of the various age groups under age 30.

About 95.5 percent of the white selectees between 18 and 30 years of age were found *negative,* about 3.5 percent were diagnosed as *arrested-acceptable* cases, and around 1.0 percent were found *positive.*

The relative frequency of *positive* cases sharply increases beginning with age 30, while the frequency of the *arrested-acceptable* cases indicates no increase until the 35-37 age group is reached. This time lag between the positive and arrested-acceptable cases is to be expected, as the latter are an outgrowth of positive cases previously developed.

Of the white selectees age 30 to 34, 94.3 percent were found *negative,* 3.3 percent were diagnosed as *arrested-acceptable* cases, and 2.4 percent were found *positive.*

Of the white selectees aged 35 to 37, 92.4 percent were found *negative,* 4.9 percent were diagnosed as *arrested-acceptable* cases, and 2.7 percent were found *positive.* The corresponding percentages for those over 37 years of age were 92.2, 4.3, and 3.5.

The number of *positive* cases among white selectees ranged thus from 10 per 1,000 selectees in the youngest age group, to 35 in the

TABLE 1

*Prevalence rates of pulmonary tuberculosis among white selectees, by age, February, 1943**

AGE GROUP	DISTRIBUTION OF 1,000 WHITE SELECTEES OF EACH AGE GROUP BY DIAGNOSIS			
	Total	Negative	Arrested-acceptable**	Positive
18 — 20	1,000	955	35	10
21 — 22	1,000	955	36	9
23 — 24	1,000	955	32	13
25 — 29	1,000	954	34	12
30 — 34	1,000	943	33	24
35 — 37	1,000	924	49	27
38 and over	1,000	922	43	35
All ages	1,000	953	35	12

* Based on a sample chosen from the individual Reports of Physical Examination and Induction (D.D.S. Form 221) on selectees examined at the Joint Army and Navy Induction Stations during February, 1943.

** Refers to "arrested" cases of pulmonary tuberculosis, acceptable for Armed Forces.

oldest age group. The frequency of *positive* cases for this group as a whole was 12 per 1,000 selectees.

The rejection rate for tuberculosis in February, 1943, was reported by the induction stations on their monthly induction reports as 11 per 1,000 white selectees, somewhat lower than that number of *positive* cases revealed by the present findings.[3] This is explained by the fact that the induction stations report for each rejectee only the *primary* cause of rejection, irrespective of the number of disqualifying defects discovered. In selecting the primary cause of rejection, precedence was given to administrative, educational, and mental over physical causes. Because of this precedence arrangement, tuberculosis was not reported as the cause of rejection in about 17 percent of the *positive* cases.

[3] The average rejection rate for tuberculosis for the entire year (1943) was 11.5 for white selectees, and 11.3 for colored selectees, substantially the same as for February of that year.

TABLE 2

*Prevalence rates of pulmonary tuberculosis among white selectees, by service commands, February, 1943**

SERVICE COMMAND	DISTRIBUTION OF 1,000 WHITE SELECTEES BY DIAGNOSIS		
	Negative	Arrested-acceptable**	Positive
I	973	21	6
II	977	13	10
III	949	38	13
IV	984	5	11
V	913	64	23
VI	888	101	11
VII	963	26	11
VIII	980	7	13
IX	973	15	12
Total U. S.	953	35	12

* Based on a sample chosen from the individual Reports of Physical Examination and Induction (D.S.S. Form 221) on selectees examined at the Joint Army and Navy Induction Stations during February, 1943.

** Refers to "arrested" cases of pulmonary tuberculosis, acceptable for the Armed Forces.

White selectees: Variations by Service Commands. As seen from Table 2, the most striking variations among the Service Commands have been with respect to the proportion of *arrested-acceptable* cases. While the IV and the VIII Service Commands, for instance, show as low as 5 and 7 *arrested-acceptable* cases of tuberculosis per 1,000 white selectees, the V and VI Service Commands show frequencies as high as 64 and 101, respectively.

These variations, however, seem to be a mere result of difference in practices of recording the diagnosis. Apparently, not all Service Commands exercise equal care in distinguishing between *negative* and *arrested-acceptable* cases, since there is no difference between these two categories from the point of view of "acceptability" into the Armed Forces. While some induction stations may tend, therefore, to list small calcified but acceptable lesions as negative, other induction

stations may tend to report a certain proportion of negative cases as arrested-acceptable.

The frequency of *positive* cases is about the same for all, except the I and V Service Commands. In the I Service Command, the frequency of positive cases is about one-half (6 per 1,000), while in the V Service Command it is about twice (23 per 1,000) that for the country as a whole (Table 2).

Only special investigations could determine whether these differences are "real," or whether they are due to differences in interpretation of the X-ray films.

Colored selectees. The prevalence of pulmonary tuberculosis among colored selectees is shown in Table 3, by age. Wider age intervals had to be used for the colored than for white selectees because of the small number of colored selectees in the sample.

Of the colored selectees aged 18 to 20, 97.0 percent were found *negative,* 1.9 percent were diagnosed as *arrested-acceptable,* and 1.1 percent were found *positive.* The corresponding percentages were 95.8, 3.1 and 1.1 for the 21-29 age group, and 95.3, 1.4 and 3.3 for those over 30 years of age.

The frequency of *positive* cases for this group as a whole was 15 per 1,000 colored selectees. As in the case of the white selectees, a lower rejection rate (11 per 1,000) was reported by the induction stations for colored selectees because of the selection of the *primary* cause.

White-colored comparisons. For comparison by race and age, the relative frequencies on the prevalence of pulmonary tuberculosis among colored selectees are juxtaposed in Table 3 with those of white.

The February data indicate a comparatively lower frequency of *arrested-acceptable* cases among colored than among white selectees. This is apparently caused by the fact that about one-half of the colored selectees came from the IV and VIII Service Commands which reported in general low frequencies for such cases. (See above: White selectees: Variations by Service Commands.)

The somewhat higher frequency of *positive* cases among colored selectees is likewise due seemingly to differences in the distribution of the colored selectees by Service Commands. (By applying the frequencies of *positive* and *arrested-acceptable* cases among white selectees of the various Service Commands to the distribution of the colored selectees by Service Commands, standardized frequencies were

TABLE 3

*Prevalence rates of pulmonary tuberculosis among selectees, by age and color, February, 1943**

AGE GROUP	DISTRIBUTION OF 1,000 SELECTEES OF EACH AGE GROUP BY DIAGNOSIS							
	White				*Colored*			
	Total	Negative	Arrested-acceptable**	Positive	Total	Negative	Arrested-acceptable**	Positive
18 — 20	1,000	955	35	10	1,000	970	19	11
21 — 29	1,000	955	35	10	1,000	958	31	11
30 and over	1,000	936	38	26	1,000	953	14	33
All ages	1,000	953	35	12	1,000	962	23	15
Estimated for males aged 18 to 39, 1940 U. S. Census	1,000	945	36	19	1,000	959	21	20

* Based on a sample chosen from the individual Reports of Physical Examination and Induction (D..S.S. Form 221) on selectees examined at the Joint Army and Navy Stations during February, 1943.

** Refers to cases of "arrested" pulmonary tuberculosis, acceptable for the Armed Forces.

obtained for the *positive* and the *arrested-acceptable* cases which differed very little from the actual frequencies among the colored selectees, importing thus no significant variation between the two racial groups.)

It may be further noted here that about 16 percent of the colored selectees (against 2 percent of the white selectees) were not given a physical examination since they were rejected for illiteracy or mental deficiency. Consequently, no chest records were obtained for these rejectees. It seems safe to assume that these rejectees came mainly from the lower income class where the prevalence of tuberculosis is expected to be relatively higher.

It can be, therefore, generally stated that the February (1943) data indicate at least as high a prevalence rate of tuberculosis among the colored as among the white selectees.

Local board rejections. The findings reported here omit rejections by local boards. Tabulations by the Selective Service System for February, 1943, show that 2 out of 1,000 white and 1 out of 1,000 colored selectees were rejected by the local boards for pulmonary tuberculosis. These were presumably institutionalized cases.

By adding these rejections to the positive cases found at the induction stations, a total frequency is obtained of 14 positive cases per 1,000 white selectees, and 16 positive cases per 1,000 colored selectees.

Estimated rates for the total population. In order to form some judgment on the probable prevalence of tuberculosis in the total population within the age range of 18 to 39, the age prevalence rates of each racial group were applied to the corresponding number of males in the total population as of 1940. The estimated rates are given in Table 3.

So estimated, the white male population aged 18 to 39 would show a prevalence rate for pulmonary tuberculosis of 19 per 1,000 males within this age group, and the colored male population of the same range would show a corresponding prevalence rate of 20 per 1,000. Combined with the rejections for tuberculosis at the local boards, both racial groups would show the same frequency of 21 per 1,000 males aged 18 to 39. (The rates estimated for the total population are much higher than those of the selectees because of the higher mean age of the total population. The mean age of the total population, to the nearest birthday, was approximated as 28.5 years for the white males and 28.4 years for the colored males aged 18 to 39, against the mean age of 22.5 years and 23.2 years of white and colored selectees, re-

spectively. In estimating the prevalence rates for the total population the assumption was made that the frequency of tuberculosis in the total population is the same as among selectees—an assumption that should be taken with some reservation.)

Disability discharges for tuberculosis. Reports on disability discharges from the Army show that only about 2 percent of the discharges were due to tuberculosis. This supplies some evidence as to the effectiveness of the chest examinations at the induction stations.

RECENT LITERATURE

USEFUL IN THE STUDY OF HUMAN BIOLOGY

In this department will be noticed the books and reprints which are currently received at the Editorial Office. Publications intended for notice here should be addressed to Dr. Lowell J. Reed, Editor of Human Biology, 615 North Wolfe Street, Baltimore - 5, Maryland, U. S. A.

I. EVOLUTION AND GENETICS

1. *Evolution — General Principles*

SHIMER, HERVEY W., and ROBERT R. SHROCK. Index Fossils of North America. A New Work Based on the Complete Revision and Reillustration of Grabau and Shimer's "North American Index Fossils." *New York* (John Wiley and Sons), 1944. Pp. ix + 837. 10¾ × 7½ inches. $20.00.

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4. *Genetics — General Principles*

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2. *Public Health and Hygiene*

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9. *Marriage and Divorce*

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III. BEHAVIOR

1. *Racial Psychology*

BARUCH, DOROTHY W., and J. ANNIE WILCOX. A study of sex differences in preschool children's adjustment coexistent with interparental tensions. *J. Genet. Psychol.,* 64: 281-303, 1944. [Bibliography of 39 titles.]

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